Cryogenic Sensor Development at LLNL

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Nov. 16, 2001

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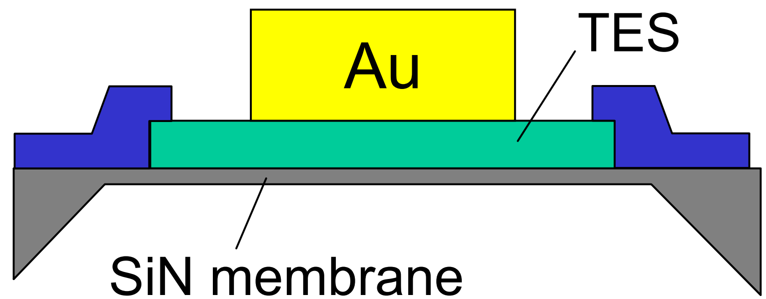
LLNL X-ray Detector

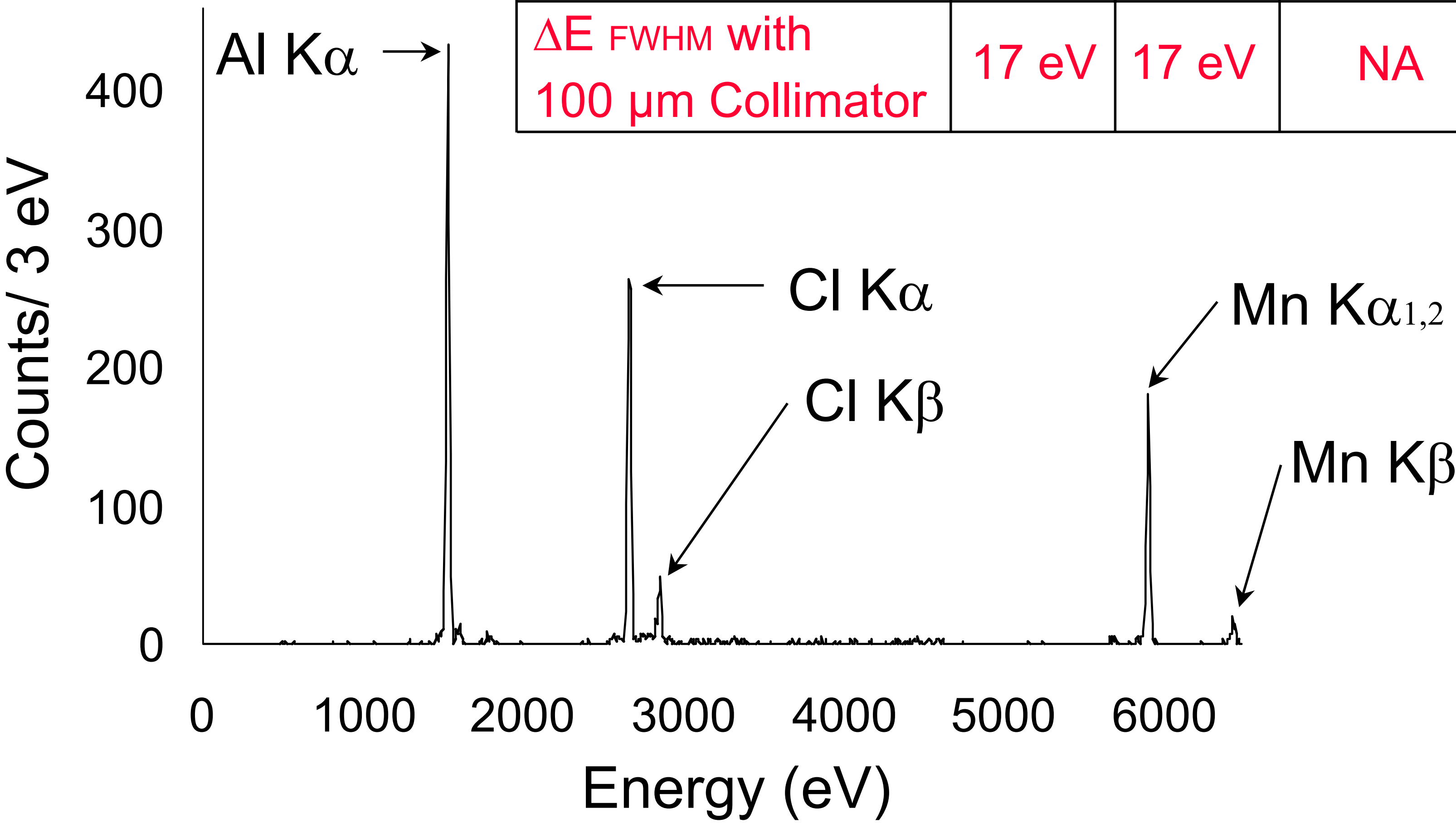
Transition-Edge Sensor made from Mo/Cu multilayer

QuickTime™ and a
Planar RGB decompressor
are needed to see this picture.



Sensor Performance

	Al Kα	Cl Kα	Mn Kα1,2
ΔE FWHM with 400 μm Collimator	23 eV	23 eV	23 eV
ΔE FWHM with 100 μm Collimator	17 eV	17 eV	NA



Frequency-Domain Multiplexing

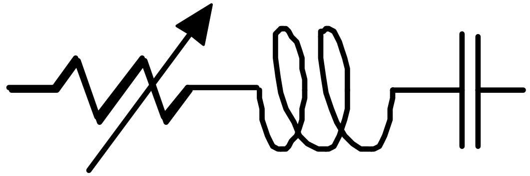
FMUX possible because signal bandwidth narrower than amplifier bandwidth

Implementation:

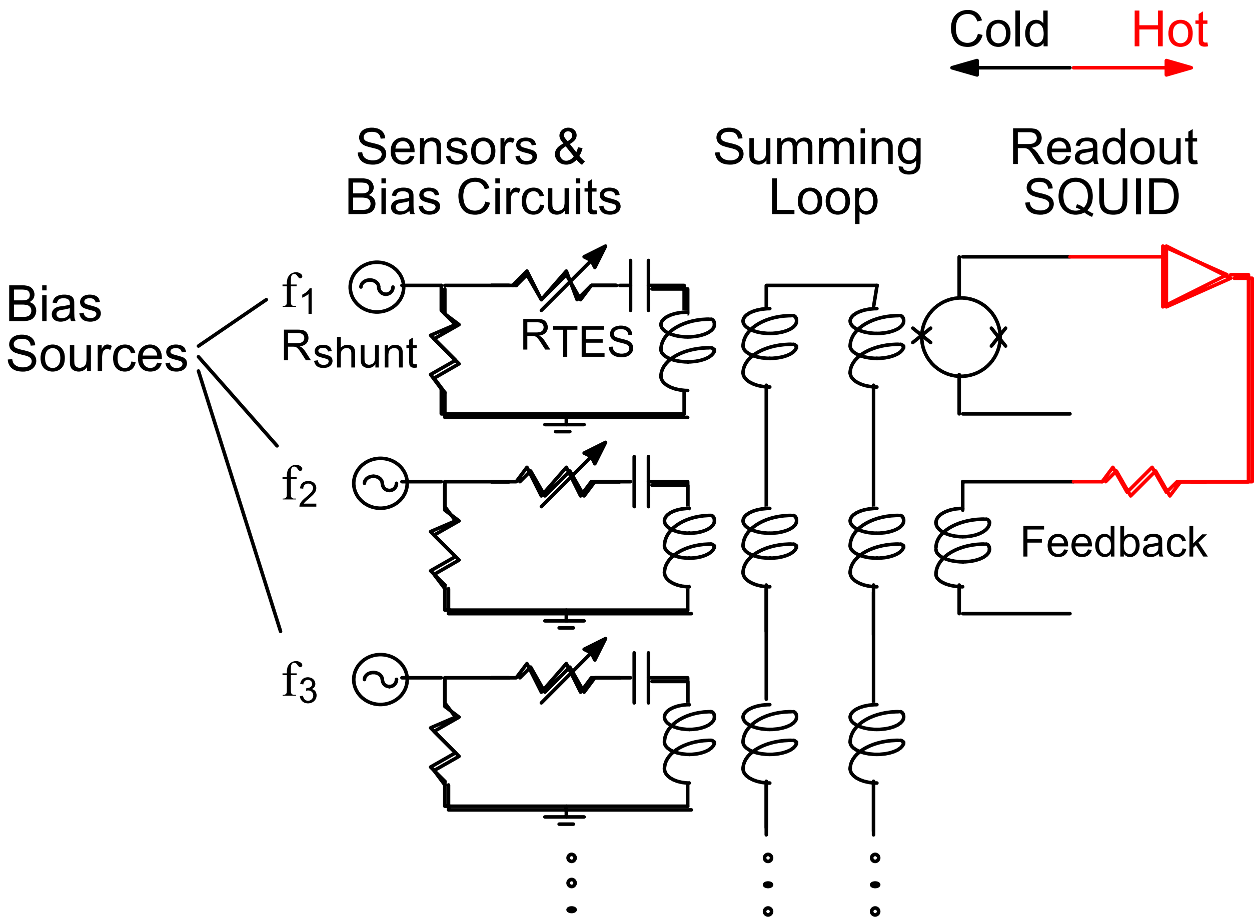
- superimpose each detector signal on different AC carrier
- sum carriers at focal plane
- measure summed signal with single amplifier
- demultiplex data at room temperature

A complication:

sensors must operate in resonant circuits to suppress noise generation at frequencies far from carrier:



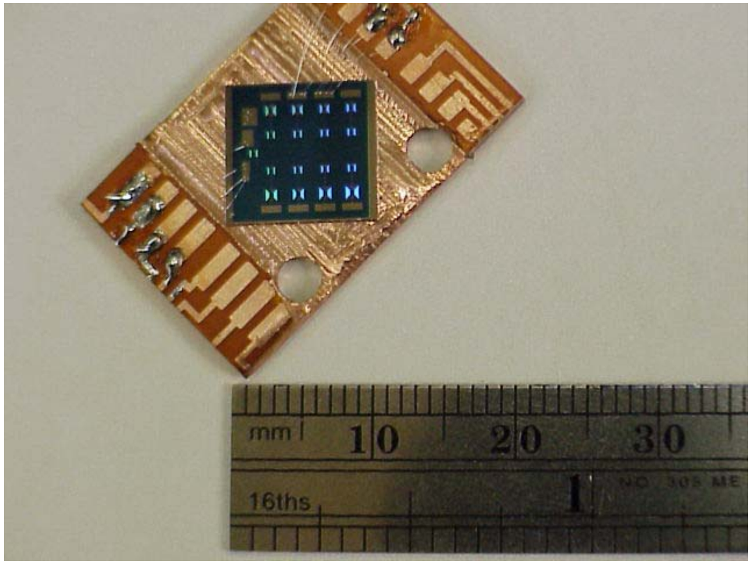
Multiplex Schematic



N x N array requires N amplifiers, £ 6N wires

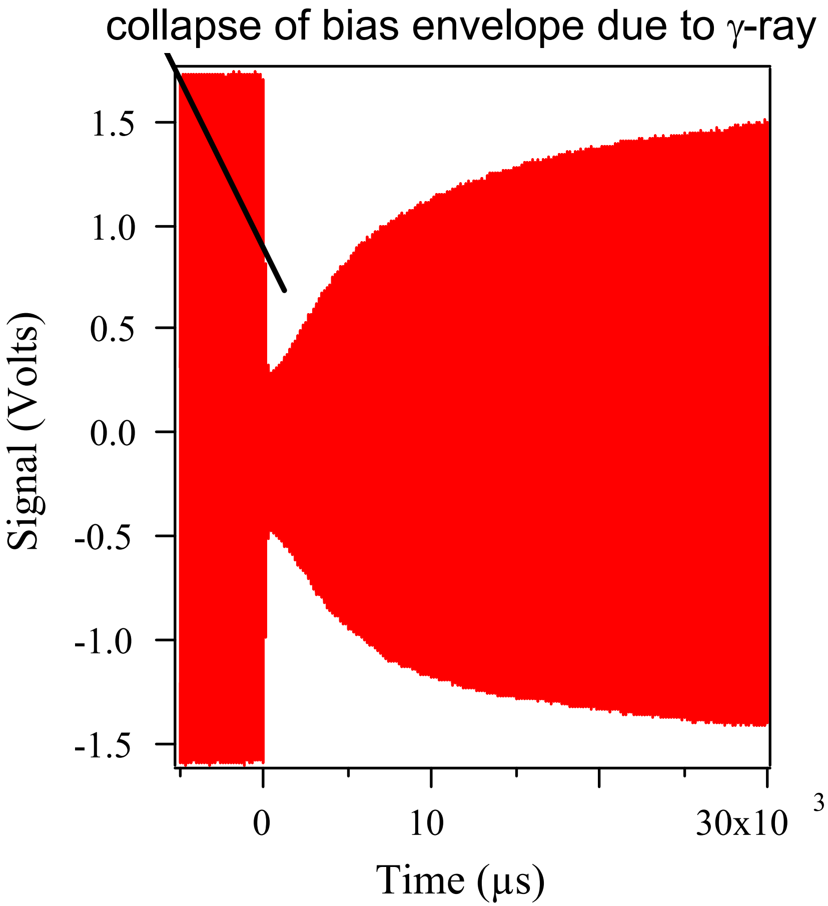
Two Pixel Measurement Planned

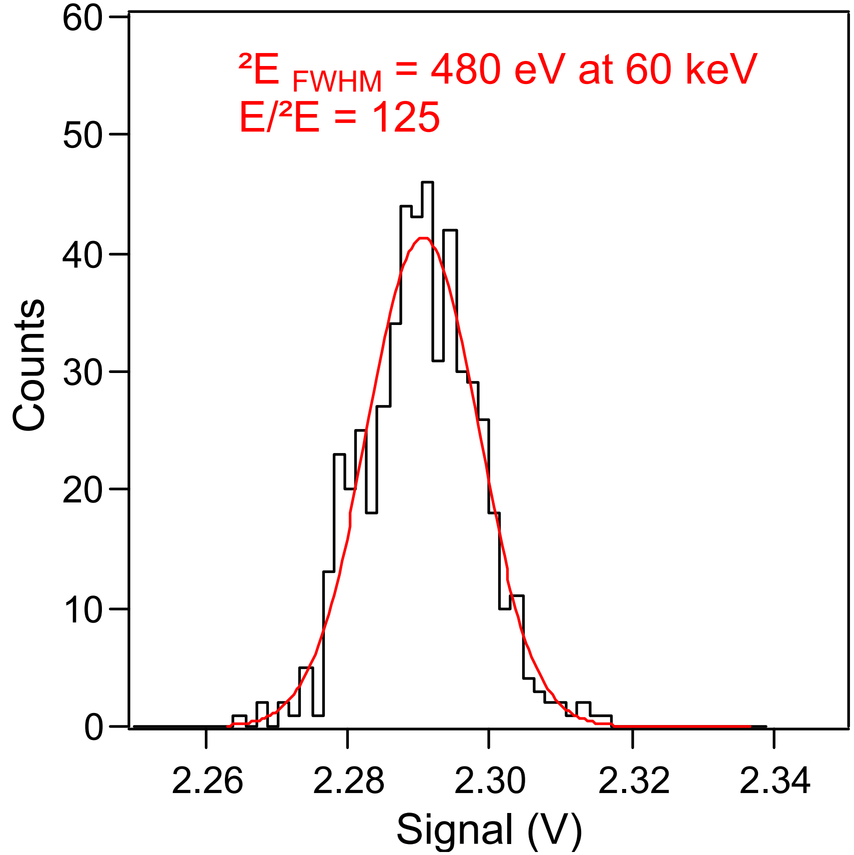
- Use gamma-ray detectors - slow: τ_{rise} ~ 100 μs, τ_{fall} ~ 1 ms.
- Use bias frequencies of 150 and 300 kHz. Summing coil from Richards & Lee at UCB:



- What's possible in the future ?
  - With current equipment, 8 pixels/amplifier, limited by SQUID noise level
  - With better, but still realistic SQUID, ~ 25 pixels/amplifier Improved flux cancellation also required: 'bucking' or 'nulling'

Sensor Response to 60 keV Photons



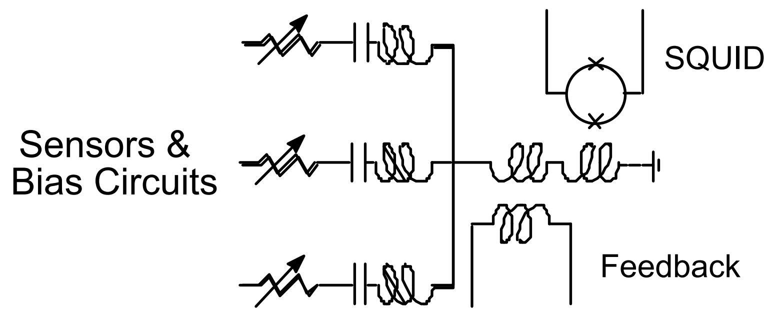


Our first photon measurements under AC bias

At same bath temperature, DC bias yields ΔE = 100 - 200 eV

Future Directions

- Other summing circuits exist:



Constraints from SQUID noise eliminated BUT flux burden higher

- Fast detector issues: (τ_{fall} ~ 100 μs)
  - Higher bias frequencies needed for stability
  - Wider signal BW
  - Smaller L's and C's (good)
  - Careful design of feedback amplifier

Conclusions

- Full-wafer process for fabrication of TES sensors developed
- $\Delta E \sim 20$ eV at 6 keV
- $\Delta E \sim 60$ eV at 60 keV
- Frequency-domain multiplexing scheme under development
- Very early results with a single pixel under AC bias are promising